METHOD, APPARATUS AND COMPUTER PROGRAM PRODUCT FOR ENHANCED CONTROL CHANNEL USAGE IN CARRIER AGGREGATION

FIELD OF THE INVENTION

[0001] The present invention generally relates to wireless communication networks, and more specifically relates to a method, apparatus and computer program product for improving control channel usage in Carrier Aggregation.

BACKGROUND

[0002] Mobile data transmission and data services are constantly making progress, wherein such services provide various communication services, such as voice, video, packet data, messaging, broadcast, etc. In recent years, Long Term Evolution LTE™, and in particular LTE-Advanced, has been specified, which uses the Evolved Universal Terrestrial Radio Access Network E-UTRAN as radio communication architecture according to 3GPP specification.

[0003] Carrier Aggregation CA is one of the key features of LTE-Advanced, which enables operators to create larger carrier bandwidths for LTE services by combining separate spectrum allocations.

[0004] The present invention basically relates to the field of Carrier Aggregation CA, which is currently specified in e.g. 3GPP LTE Release 10 and enhanced in 3GPP LTE Release 11 regarding LTE Advanced (LTE-A). As already indicated above, CA allows increasing the transmission/reception bandwidth by aggregating cells (a.k.a. Component Carriers).

[0005] In general, CA introduces the concepts of a Primary cell (PCell) and Secondary cell(s) (SCell). A user equipment UE which is capable for CA selects a PCell, and one or plural SCell(s) may be allocated to the CA-capable UE by the radio resource control RRC. The activation/deactivation of these SCells is controlled by the media access control MAC layer. The SCells may operate on the same frequency band as the PCell, or on a different band.

[0006] That is, in order to allow a user equipment UE to use the additional cell(s), the secondary cell(s) SCell(s) first need to be added by RRC and then activated by MAC. The prominent benefits of Carrier Aggregation include increased peak data rates, possibility to aggregate fragmented spectrum and fast load balancing.

[0007] More specifically, the present invention relates to the usage of Physical Uplink Control Channel (PUCCH) format 3 (F3) and PUCCH format 1b with channel selection (F1bwcs) as specified in 3GPP TS [36.211, 36.212 and 36.213]. The new PUCCH formats were introduced in 3GPP LTE Release 10 for the purpose of UE feedback for Carrier Aggregation.

[0008] The new PUCCH formats are mandatory to be used when the UE is aggregated with one or more SCells.

[0009] According to the above specifications, a base station eNB assigns four PUCCH F3/F1bwcs resources (or four resource pairs) per CA-capable UE by L3 RRC. Then, in a given transmission time interval TTI when the UE is scheduled in the downlink on SCell(s), only one of the four resources (or one resource pair) is selected and indicated to the UE by L1/L2 DCI (downlink control information)/PDCCH signalling (e.g. via the "TPC command for PUCCH" field in the DCI/downlink PDCCH assignment).

[0010] Thereby, the 3GPP related constrains are, in view of the PUCCH F1bwcs, if a UE uses a PUCCH F1bwcs resource (or a resource pair) in a given TTI to feedback ACK/NACK(s) on a given cell with the PCell role, then no other UE can use this resource (or a resource pair) in the same TTI on the same cell with the PCell role (otherwise an over-the-air resource collision would occur and the UL feedback fails). Further, in view of PUCCH F3, if a UE uses a PUCCH F3 resource in a given TTI to feedback ACK/NACK(s) on a given cell with the PCell role, then no other UE can use this resource in the same TTI on the same cell with the PCell role. If a UE gets a PUCCH F3 resource assigned by a downlink assignment due to downlink transmission on an SCell in a TTI, then the UE needs to get exactly the same resource by the downlink assignment corresponding to downlink transmission on additional SCell (s) in the same TTI (otherwise the UE will treat the multiple downlink assignments (due to downlink transmission on multiple SCell) as inconsistent downlink PDCCH information and the downlink transmission fails).

[0011] It is apparent that PUCCH F3/F1bwcs resource overbooking will be used by practical implementations upon the configuration of the resources by RRC for many UEs. For example, without overbooking if a unique resource is assigned for each UE during SCell(s) configuration then 100 UEs configured with SCell(s) and PUCCH F3 would require 20 (5 PUCCH F3 resources per UL PRB are possible) UL PRBs to be used just for PUCCH F3 (25 UL PRBs are available in case of a 20 MHz cell). Note that 100 UEs configured with SCell(s) per PCell is the current Nokia implementation, however, already now higher numbers are requested by operators including the extreme case when all UEs in the cell are configured with SCell(s).

[0012] Additionally, on the one hand, a high number of UEs per PCell with activated SCell(s) and scheduled per TTI is required by operators, and, on the other hand, a high number of SCell candidates per PCell is required by operators.

[0013] The above requirements and constrains pose the problem of an efficient PUCCH F3/F1bwcs resource assignment which is the scope of this invention.

[0014] Hence, an optimization of the control channel usage in Carrier Aggregation is required.

SUMMARY OF THE INVENTION

[0015] Therefore, in order to overcome the drawbacks of the prior art, it is an object underlying the present invention to provide enhanced control channel usage in Carrier Aggregation.

[0016] In particular, it is an object of the present invention to provide a method, apparatus and computer program product for enhanced control channel usage in Carrier Aggregation.

[0017] This object is achieved by a method, apparatus and computer program product as defined in the independent claims.

[0018] According to a first aspect of the present invention, there is provided a method for managing control channel usage in Carrier Aggregation, comprising defining a time reuse factor and a time reuse pattern for a Physical Uplink Control Channel resource on a Primary Cell for enabling time multiplexing the subframes of the resource, and assigning a Physical Uplink Control Channel resource element to a requesting User Equipment by using colliding resources in